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Thrombolysis for Frostbite: A Case Study and Clinical Considerations

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A B S T R A C T

Frostbite injuries are becoming more common in the civilian population and are frequently associated with homelessness, mental illness, and alcohol and drug use and abuse. Taking care of these patients requires a multidisciplinary approach, initially by emergency medicine, the burn service, and interventional radiology, and eventually involving case management, social services, and occupational and physical therapy. Timely and rapid rewarming in conjunction with catheter-directed intravascular thrombolysis interventions can restore adequate perfusion to the patient's compromised digits. To improve patient outcomes, it is essential to obtain proper imaging and, if appropriate, immediately initiate an interventional radiology consultation for urgent thrombolysis treatment. This article presents a clinical case study of a patient who suffered frostbite injuries and underwent intravascular thrombolysis interventions that spanned a 24-hour period and required two interventional radiology procedures. Nursing care considerations and thrombolysis management in the emergency department, radiology department, and intensive care unit are reviewed.

Case study

The patient is a 54-year-old African American male who admitted to drinking heavily on a cold January evening. At some point, he went outside of his home and passed out on the ice and snow from inebriation. The next morning, he was found by emergency medical services and transported to an outside hospital for a full evaluation. The patient was noted to be hypothermic with a core temperature of 95.5F(R), and he had blisters on both hands consistent with frostbite injury. He was unable to recall how long he had been exposed to the outside elements, and so the official time of injury is unknown. A computerized tomography angiography (CTA) of the upper extremities was performed, which showed threadlike opacifications of the lateral proper digital artery of the right fourth digit and the left fifth digit. He was rewarmed and treated with heat packs and blankets and his hands were wrapped in nonocclusive dressings with 3% bismuth tribromophenate before his transfer to Massachusetts General Hospital (MGH) for further management.

Upon arrival to the emergency department (ED) at MGH, the patient was found to be normothermic with stable vital signs and endorsing minimal pain in both hands. He denied any past medical or surgical history, allergies, or medication usage. He stated he smokes one pack of cigarettes daily and uses recreational marijuana. The patient admitted to drinking a half a pint of vodka and several beers every week.

Examination of both hands showed no discoloration of palms or dorsal hands. One centimeter blisters were noted on multiple digits, and all digits were discolored with dark, black skin to varying degrees (Figure 1). The patient reported that he had no sensation to any of his fingertips (bilaterally) and he demonstrated minimal flexion and extension of his digits. The burn service was consulted to treat the edema, blisters, and skin discoloration and performed a bedside bilateral hand debridement. When the debridement was complete, the patient had healthy wound beds (Figure 2) which were then covered by antimicrobial dressings. At approximately 24-36 hours after injury, interventional radiology (IR) was consulted for intra-arterial tissue plasminogen activator (tPA) treatment.

The patient was brought to the IR suite and was informed of the risks of the procedure, including bleeding and infection. He signed his informed consent and was placed supine on the table by a team

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Figure 1. Right hand with blisters on digits 1-5 consistent with frostbite injury.

that included the interventional radiologist, a radiology fellow, a radiology technologist, and a registered nurse. Bilateral groins were prepped in standard sterile fashion and the patient received 10 mL of lidocaine (1%) local anesthetic to the right groin. He was placed on continuous cardiac and oxygen saturation monitoring and intravenous fentanyl and midazolam were given to achieve a moderate sedation state.

Right femoral artery access was achieved, and a 4-French sheath was inserted. Nitroglycerin 400 mcg, in divided doses to bilateral upper extremities, was administered intra-arterially to minimize vasospasm as a potential etiology of the patient's decreased perfusion. Contrast media were then injected and bilateral upper-extremity angiographies were performed. Normal perfusion was noted to all phalanges of the left hand. Decreased perfusion to the 4th and 5th digits of the right hand was observed (Figure 3), and a decision was made to treat the right hand with tPA. The sheath was left in place and tPA was set at a rate of 1 mg/hour via a 4-French GlideCath™ (Terumo Medical Corporation, Somerset, NJ) that terminated in the right distal brachial artery. In accordance with hospital protocol, tPA was ordered at a rate of 1 mg/hour per extremity with a maximum dose of 2 mg/hour (Tavri et al., 2016). Orders included q4-hour fibrinogen levels, with parameters to

Figure 2. Right hand s/p bedside debridement.

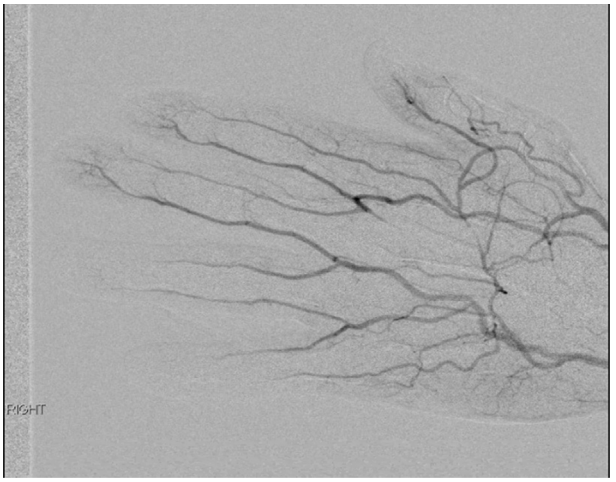

Figure 3. Right upper-extremity angiography demonstrating decreased perfusion to 4th and 5th digits.

decrease the tPA dose by half if the fibrinogen level is less than 150 mg/dL and to stop the infusion for fibrinogen levels less than 100 mg/dL. In addition, the patient was treated with intravenous peripheral heparin at 5 units/kg/hour. After the procedure, the patient was transferred to the intensive care unit (ICU) for continued close monitoring and his surgical team consulted occupational therapy (OT), physical therapy (PT), and case management.

The patient was monitored overnight for q4-hour fibrinogen levels and partial thromboplastin time results, which did not require adjustments of his medications. He underwent q1-hour circulation, sensory, and motor (CSM) checks of his right hand as well as q1-hour femoral and pedal pulse checks. He was ordered for flat bedrest and watched closely for signs of bleeding systemically and at his right groin site. He experienced intermittent throbbing pain that was well managed with oxycodone and acetaminophen. Both hands were elevated on pillows and his hand wounds were redressed with bacitracin, nonadhering dressings, and covered with dry sterile dressings.

Twenty-four hours later, the patient returned to IR and received a 100 mcg intra-arterial nitroglycerin administration and saline flush followed by a right upper-extremity angiogram, which demonstrated adequate blood flow to all 5 digits (Figure 4). The tPA and heparin were discontinued, and the catheter and sheath were removed. A decision was made to use an AngioSeal™ (Terumo Interventional Systems, Somerset, NJ) closure device to mitigate the risk of bleeding. The patient was transferred back to the ICU for continued monitoring. The next evening, approximately 72-84 hours after his initial injury, the patient was discharged home with continued OT and PT. He returned to the burn service clinic 12 days later and his frostbite wounds were almost all closed (Figure 5).

Background

Frostbite is a medical condition resulting in tissue damage caused by exposure to cold. The spectrum of frostbite injury ranges from superficial injury to severe damage of the deep tissue (Gross & Moore, 2012). The severity of injury from frostbite is multifactorial and directly correlated to the duration of exposure to the cold, the ambient temperature, the depth of injury, and the amount of frozen tissue (Fudge, 2016). In an effort to conserve body heat, the human body's initial response to cold exposure is vasoconstriction, which can significantly limit blood flow in the smaller vessels, putting

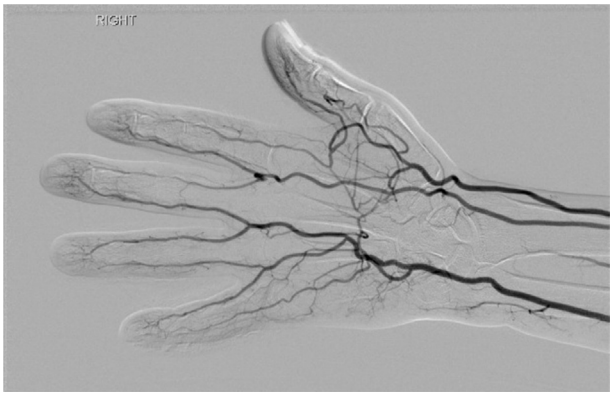

Figure 4. Post-thrombolysis treatment right upper-extremity angiography demonstrating adequate perfusion to 4th and 5th digits.

them more at risk for injury. Therefore, common sites of frostbite injury include fingers, toes, nose, and ears (Fudge, 2016).

Frostbite is divided into four levels of progressive tissue injury. First-degree frostbite is characterized by numbness, erythema, and mild edema to the affected area. Although there is no tissue infarction associated with this stage of frostbite, there can be mild sloughing of the epidermis as well as a yellow or white slightly raised area of plaque surrounding the area of injury (McIntosh et al., 2011). Patients with second-degree frostbite may exhibit significant edema and development of blisters, which dry within several weeks to produce a dark eschar (Harirchi et al., 2005; McIntosh et al., 2011). Third-degree frostbite is characterized by development of hemorrhagic blisters, significant burning pain while rewarming, blue or gray discoloration of the skin, development of thick eschar, and significant sensitivity to the cold (Harirchi et al., 2005). Patients who exhibit signs and symptoms of fourth-degree frostbite have extensive involvement into the muscle, bone, and tendons (Harirchi et al., 2005). Fourth-degree frostbite extends through the dermis and into subcutaneous tissues thereby resulting in necrosis of the muscle and bone (Fudge, 2016).

Figure 5. Frostbite wounds all nearly closed 12 days after discharge.

Historically, frostbite had a higher incidence among military personnel. However, in recent years, the epidemiology has evolved to a higher incidence among civilians. Risk factors for injury sustained from frostbite include prolonged exposure, inadequate protection from the cold, and low temperatures. Patients who are at higher risk include those with a history of substance abuse, homelessness, psychiatric disease, smoking, trauma, diabetes, dementia, Raynaud's disease, previous cold injury, and peripheral vascular disease (Gross & Moore, 2012).

Discussion

Formerly, treatment of frostbite injury involved only supportive care, including rewarming and debridement, which focused on the overarching goal of preserving viable tissue while preventing infection (Ibrahim et al., 2015). This method of treatment often resulted in amputation as it focused only on the initial phases of frostbite injury by treating the formation of ice crystals that occur in the intracellular and extracellular space (Tavri et al., 2016). This treatment method did not account for microvascular thrombi, which is a late vascular injury in frostbite and the predominant cause of tissue necrosis and ischemia (Ibrahim et al., 2015; Patel et al., 2017; Tavri et al., 2016). Today, management of frostbite has expanded into a multidisciplinary approach to achieve reperfusion to the affected body part with a direct focus on intra-arterial thrombolysis.

Management of hypothermia and frostbite should begin in the prehospital setting when it can be safely implemented and the injured site is not at risk to re-freeze. Moving the patient out of the cold and wind and removing wet clothing can help reduce further injury. Rubbing the extremity is never advised because of the potential to further cellular damage (Handford et al., 2014).

Upon arrival to the hospital, the patient should be assessed and medically stabilized before initiating invasive interventions to save frostbitten areas. Underlying trauma, hypothermia, intoxication, or other causes should be managed first. Patients should be monitored for arrhythmias, and methods of rewarming, including passive (blankets) and active (warmed intravenous fluid, warmed oxygen, or lavage) techniques, should be used until the patient has achieved a normothermic response (Handford et al., 2014). Rewarming of a partially or completely frozen extremity can be an uncomfortable process for the patient. Ideally, the affected site should be rewarmed for 15m-1 h in warm water (38 C) until the tissue becomes supple and the skin becomes red/purple in color (Handford et al., 2014).

Once the patient is medically stabilized, the team should consider consulting interventional radiology to urgently improve flow to the affected frostbitten site if rewarming did not achieve adequate perfusion, which is best assessed using a CTA. Frequently, frostbite injuries occur on nights and weekends when patients have a higher tendency to be outside and exposed to colder temperatures. Therefore, notifying and assembling the IR team quickly, so they can safely prepare for and perform the intervention, is the optimal goal. In this case study, the delay in IR intervention was attributable to an unknown time of injury as well as a significant delay of more than 24 hours before the patient was transferred to the tertiary care center.

The nurse's role in IR remains consistent with other intravascular procedures, which includes verifying the patient is a candidate for nursing-administered moderate sedation, assessing the patient's ability to lie flat, and assessing and documenting pulses distal to the access site before the procedure. The nurse should clarify that consent was obtained, participate in the time-out, and assess the patient's pain and sedation level while monitoring for potential arrhythmias. It is important to manage the patient's

sedation while being cognizant of the underlying cause of exposure. For example, if the patient struggles with alcohol addiction, the nurse may need to closely monitor for tachycardia and consider administering higher doses of benzodiazepines to manage early withdrawal and/or to achieve an appropriate level of sedation during the procedure. Once the necessary thrombolytic interventions have been performed, it is necessary to ensure that the sheath is secured by suture(s) and occlusive clear dressings to minimize the risk of bleeding and infection. Transfer boards should be used to minimize patient movement and potential sheath dislodgement. Ongoing close assessment of the injured extremity as well as the CSM of the extremity distal to the access site is paramount to the patient's recovery.

Conclusion

Before the introduction of thrombolytic therapy, the foundation of frostbite management was targeted toward active rewarming, wound care, ongoing assessment, and careful monitoring to understand if the patient's limb was headed toward recovery or amputation (Gross & Moore, 2012). With the advent of interventional tPA as a treatment strategy for frostbite, now the patient may have the ability to have the affected limb reperfuse, as catheter-directed thrombolysis occurs and blood returns to the injured site, ultimately restoring function. IR plays a vital role in this frostbite treatment strategy working collaboratively with the ED, burn service, and ICU to maximize outcomes for the patient. Radiology nurses have an essential role in the care of the frostbite patient and must understand the complex nature of the injury, the treatment plan, the patient's underlying history and issues, and the support services necessary to facilitate and provide best care practices for frostbite patients.

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